FHWA/ NJ 98-003-7730

EVALUATION OF GEOCOMPOSITE LONGITUDINAL EDGE DRAINS

February 1998

by

Victor E. Mottola, P.E.
and
Gerald J. Kauffman, P.E.

Prepared by
New Jersey Department of Transportation
Quality Assurance, Improvement, and Research

In Cooperation With

U.S. Department of Transportation
Federal Highway Administration

NJ
TE
215
M67
1998

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/NJ-98-003-7730		

4. Title and Subtitle	5. Report Date
Evaluation of Geocomposite Longitudinal Edge Drains	February 1998
	6. Performing Organization Code NA

7. Author(s)	8. Performing Organization Report No.
Victor E. Mottola, P.E. and Gerald J. Kauffman, P.E.	98-003-7730

9. Performing Organization Name and Address	10. Work Unit No.
New Jersey Department of Transportation 1035 Parkway Avenue Trenton, NJ 08625	11. Contract or Grant No.
	13. Type of Report and Period Covered Final Report 6/88 to 6/90
12. Sponsoring Agency Name and Address Federal Highway Administration U.S. Department of Transportation Washington, D.C.	14. Sponsoring Agency Code

15. Supplementary Notes

Prepared in cooperation with the Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

16. Abstract

This report documents research done by the NJDOT on Geocomposite Edge Drains. It is separate from the report on other CPR techniques evaluated in this study in an attempt to achieve early implementation of the results. A draft copy of this report had been distributed to all interested operating groups in the Department, and several projects were constructed using the results and recommendations made in this report.

This portion of the research was conducted in three phases. Phase I of the study consisted of a literature review and evaluation of the state-of-the-art of geocomposite edgedrains and development of a preliminary specification. Phase II was a laboratory investigation, including the use of a lysimeter to screen perspective candidates. Phase III consisted of a field installation, evaluation construction techniques, costs and performance (flow measurements).

Tentative guidelines for selecting suitable candidate projects are included in the report in addition to construction and materials specifications.

NJ
TE
215
M67
1998

17. Key Words	18. Distribution Statement
Geocomposite Edge Drains Subsurface Drainage CPR	Copies available upon request

19. Security Classif (of this report)	20. Security Classif. (of this page)	21. No of Pages	22. Price
Unclassified	Unclassified	50	

Form DOT F 1700.7 (8-69)

Disclaimer Statement

The contents of this report reflect the views of the author(s) who is (are) responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the New Jersey Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to those individuals who have provided assistance and advice needed to complete this work.

Appreciation is expressed to Mr. Bob Stewart, the Resident Engineer for his interest and help and without whose cooperation our job would have been impossible.

Thanks also go to Messrs. Tony Chmiel, John Salt, Ken Jaslar and Bill Whitfield of our Research staff who took samples, ran tests and collected and analyzed data.

TABLE OF CONTENTS

		Page
I.	INTRODUCTION	1
	1. Background	1
	2. Research Approach	4
II.	LITERATURE SEARCH AND INITIAL INVESTIGATION	5
	1. Flow (In Plane)	5
	2. Compressive Strength	6
	3. Core Material	6
	4. Filter Fabric	8
	5. Product Dimensions	8
III.	PRODUCT SELECTION	9
IV.	CONSTRUCTION PLAN DEVELOPMENT	9
V.	LABORTORY EVALUATION	12
	1. Flow	12
	2. Compressive Strength	15
	3. Evaluation of Existing Subbase Soils	17
VI.	FIELD EVALUATION	18
	1. Installation	18
	2. Outflow Measurements	19
	3. Faulting and Pumping Survey	19
VII.	COST ANALYSIS	21
VIII.	RECOMMENDATIONS	28
IX.	DESIGN GUIDELINES	28

APPENDICES

A. Calculations for Selection of Geocomposite Edgedrains A-1

B. Construction Costs for Geocomposite Edge Drains B-1

C. Geocomposite Edge Drain Specifications C-1

D. Photo Appendix D-1

INDEX OF FIGURES AND TABLES

Figure Page

1. Type X Underdrain 2
2. Geocomposite Edgedrains 3
3. Compressive Strength Testing of Geocomposite EdgeDrain Mtls. 7
4. Location of Geocomposite Edge Drains - Route I-295 11
5. Lysimeter To Test Flow From Edge Drains 13
6. Plan View of Lysimeter for Flow Testing of Geocomposite Edge Drains 14
7. Design Chart for Rigid Pavements Based on Using Mean Values for Each Input Variable 25
8. Design Chart for Rigid Pavements Based on Using Mean Values for Each Input Variable 26

Table

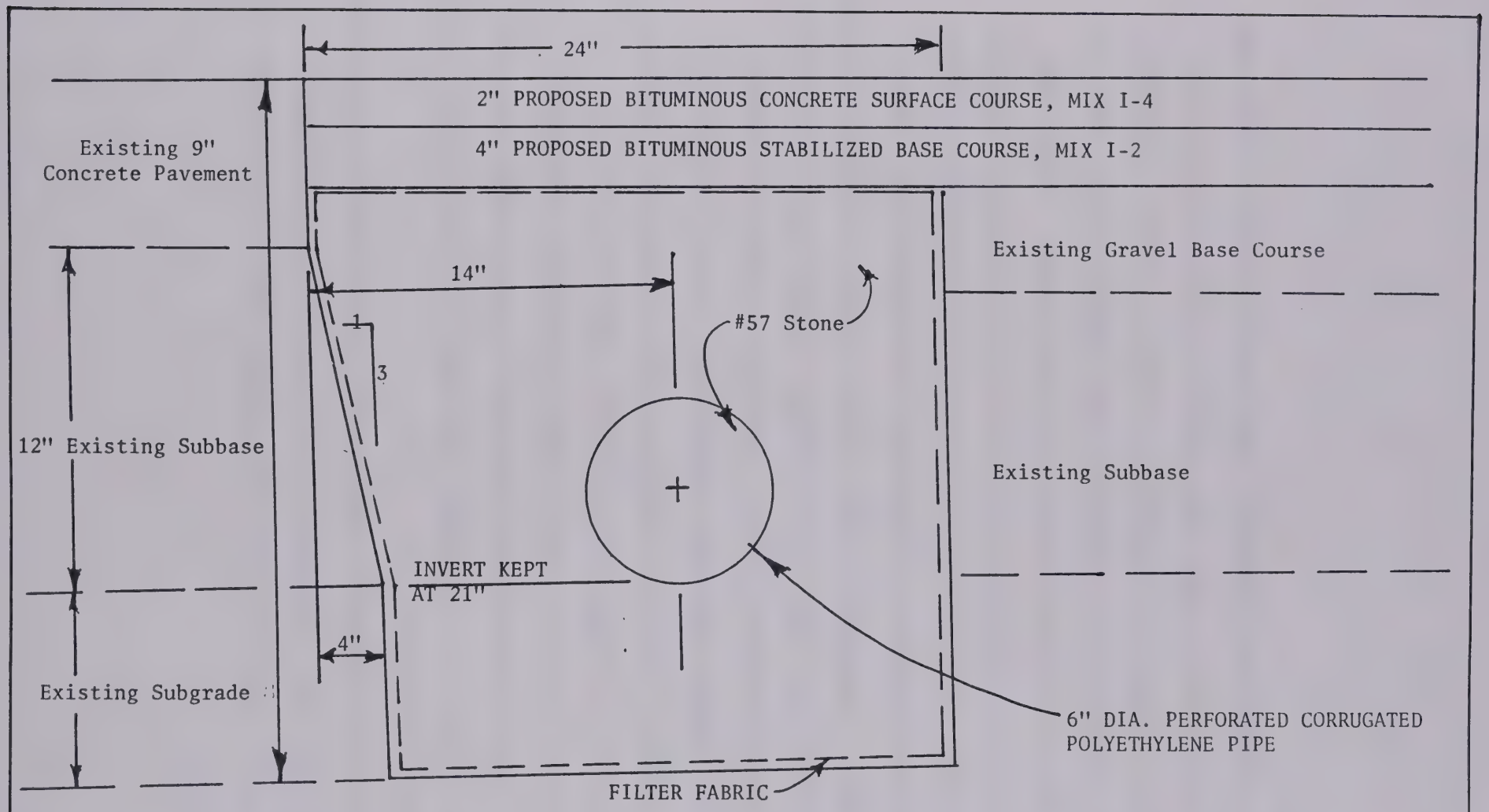
1. Literature Evaluation of Geocompsoite Edge Drains for Route I-295, Sec. 3F, 4K, 5K 10
2. Geocomposite Longitudinal Edge Drains: NJDOT Research Laboratory REsults 16
3. Geocomposite Longitudinal Edge Drains Preliminary Outflow Results 20

I. INTRODUCTION

1. Background

The need for subsurface pavement drainage is a well established fact which can be traced back to the 19th century roadbuilder Macadam. In new concrete pavements, complete subsurface drainage systems, consisting of a drainage layer, longitudinal edgedrains and outlets, have been an integral part of every NJDOT design since the early 1980s. Pavements constructed prior to this time in New Jersey relied on bank-run subbases and outlet drain spaced every 350 feet to provide the necessary drainage. Because of subbase variability and relatively low permeability, this design sometimes proved inadequate, with resultant early pavement distress such as pumping and slab cracking. Retrofitting longitudinal underdrains is a Concrete Pavement Restoration (CPR) technique designed to remove subsurface water from subbase and base layers and, in turn, reduce the rate of faulting, pumping, and slab cracking of these existing concrete highways. Current NJDOT strategy is to retrofit existing concrete pavements during CPR work with the Type X underdrain which consists of a filter fabric lined trench backfilled with select, open-graded stone and 6" perforated pipe (Figure 1). A typical bid price for this edgedrain in New Jersey is $14 per lineal foot.

Recently, several manufacturers have recognized the need for low cost edge drain products and have introduced the concept of a Geocomposite Longitudinal Edge Drain which consists of a polyethylene core wrapped in filter fabric (Figure 2).

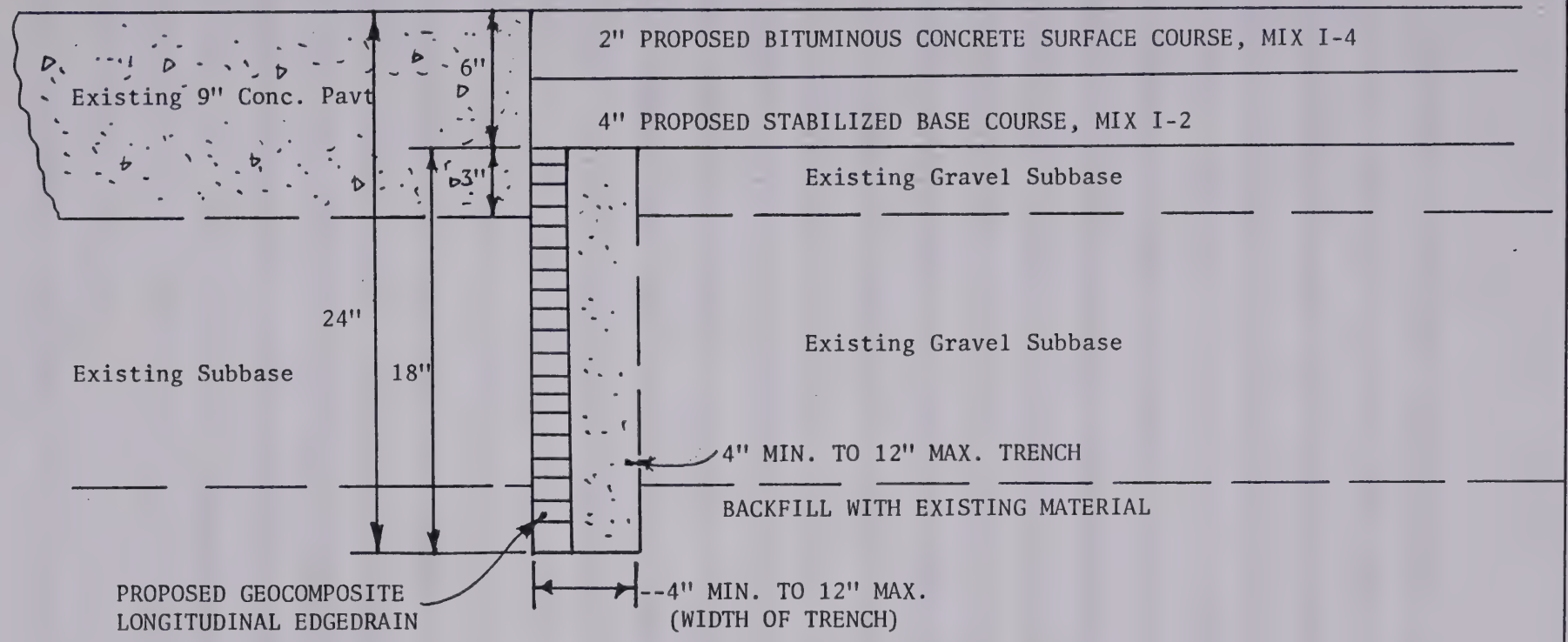


TYPE X LONGITUDINAL UNDERDRAIN - SECTION VIEW

EDGE OF CONCRETE PAVEMENT IN SHOULDER AREA, ROUTE I-295, SEC. 3F, 4K, 5K

Not To Scale

Figure 1 - Type X Underdrain



EXPERIMENTAL GEOCOMPOSITE LONGITUDINAL EDGEDRAIN - SECTION VIEW

SHOULDER AREA I-295 N.B. STA. 644+00 TO STA. 704+00

Not To Scale

Figure 2 - Geocomposite Edge Drain

The advantages of the geocomposite drain include low cost and ease of installation. Material costs range from $1.50 to $2.00 per L.F. A minimum 4" trench is required and backfilling is conducted using existing material, thus eliminating the need for expensive filter fabric and select stone.

As part of a five-year, FHWA-funded study designed to evaluate Cost Effective Concrete Pavement Restoration/Drainage Techniques, Research is currently evaluating the laboratory and field performance of geocomposite edge drains. The drains were installed by a change order requested by Research on an ongoing CPR construction project. The main objective of the evaluation is to determine if the geocomposite drains can be installed at a lower cost than the Type X stone underdrain and yet provide similar flow capacity and sufficient strength under traffic loading. A full construction report detailing the laboratory evaluation, construction procedures, and post construction monitoring of the Geocomposite Edge Drains will be published and distributed during the spring of 1991.

2. Research Approach

The approach used to evaluate the geocomposite edge drains consisted of a literature review and evaluation of the state-of-the-art, laboratory testing of various types of products and subsequent preliminary specification development, installation of the drains and preliminary comparisons of actual flow performance.

II. LITERATURE SEARCH AND INITIAL INVESTIGATION

Reports from Illinois DOT, Indiana DOT and the Federal Highway Administration (Geocomposite Drains, Volume I, Engineering Assessment and Preliminary Guidelines, FHWA/RD-86/171) were reviewed for pertinent information regarding the use of geocomposite longitudinal edge drains for subsurface drainage of highways. Approximately 10 geocomposite edgedrain manufacturers were contacted and invited to submit product samples and literature for evaluation. The reports, manufacturer's literature, and our hydraulic and geotechnical calculations indicate that the geocomposites should meet the following criteria.

1. Flow (In Plane) - 600 gph (@ 1.0%, 12" width) in accordance with ASTM D-4716

Subbase soils constructed 10 to 20 years ago along N.J. portland cement concrete interstate highways are relatively impermeable. Laboratory testing conducted during a NJDOT Research Study indicate that these existing subbase soils have permeabilities of less that 1 ft/day.(1) The flow capacity of geocomposite edgedrains should be sufficient to drain the relatively impermeable subbase, and also convey roof water that flows through the longitudinal joint at the concrete pavement-bituminous concrete shoulder interface. Hydraulic calculations indicate that maximum flow into the edge drain from the subbase and the longitudinal shoulder joint can be conservatively estimated at 400 gph (Appendix A). Using a Factor of Safety of 1.5 to allow for future plugging of fabric with fines, the minimum flow capacity required = 1.5(400 gph) = 600 gph.

(1)NJDOT Research Study FHWA 7775, "Permeability of New Jersey Subbases".

2. Compressive Strength - 60 psi min. (at 50% deflection of core-fabric thickness

Geotechnical calculations indicate that a standard 100 psi truck tire exerts a maximum lateral force of about 30 psi on an in-place geocomposite edge drain at a depth of 2 feet below the pavement surface (Appendix A). Using a F.S. of 2 to allow for cyclic traffic loading, plastic core creep, and compaction crushing resistance, the minimum Compressive Strength Required = 2(30 psi) = 60 psi.

The filter fabric should be bonded to each node of the core, or construction of the core should prevent intrusion of the fabric into the hydraulic opening during compressive strength testing.

Compressive strength testing of the geocomposite was determined in accordance with the experimental NJDOT procedure outlined in Figure 3. This procedure is designed to determine the strength of the core-fabric interface under soil loading as opposed to other procedures which determine core strength under direct, rigid plate loading. Laboratory soil loading of the core-fabric interface is a close approximation of the lateral soil loading that occurs in the field. (Photos - Appendix #1 and #2.)

3. Core Material - Shall be High Density Polyethylene (HDPE) Thickness = 1" min.

The FHWA report indicates that high density polyethylene (HDPE) is resistant to most chemicals and has good weatherability when mixed with carbon black. Other potential core materials such as Styrene-ABS (too brittle), Nylon (only fair weatherability, not acid resistant), and Polystyrene (poor weatherability) do not perform as well as HDPE.

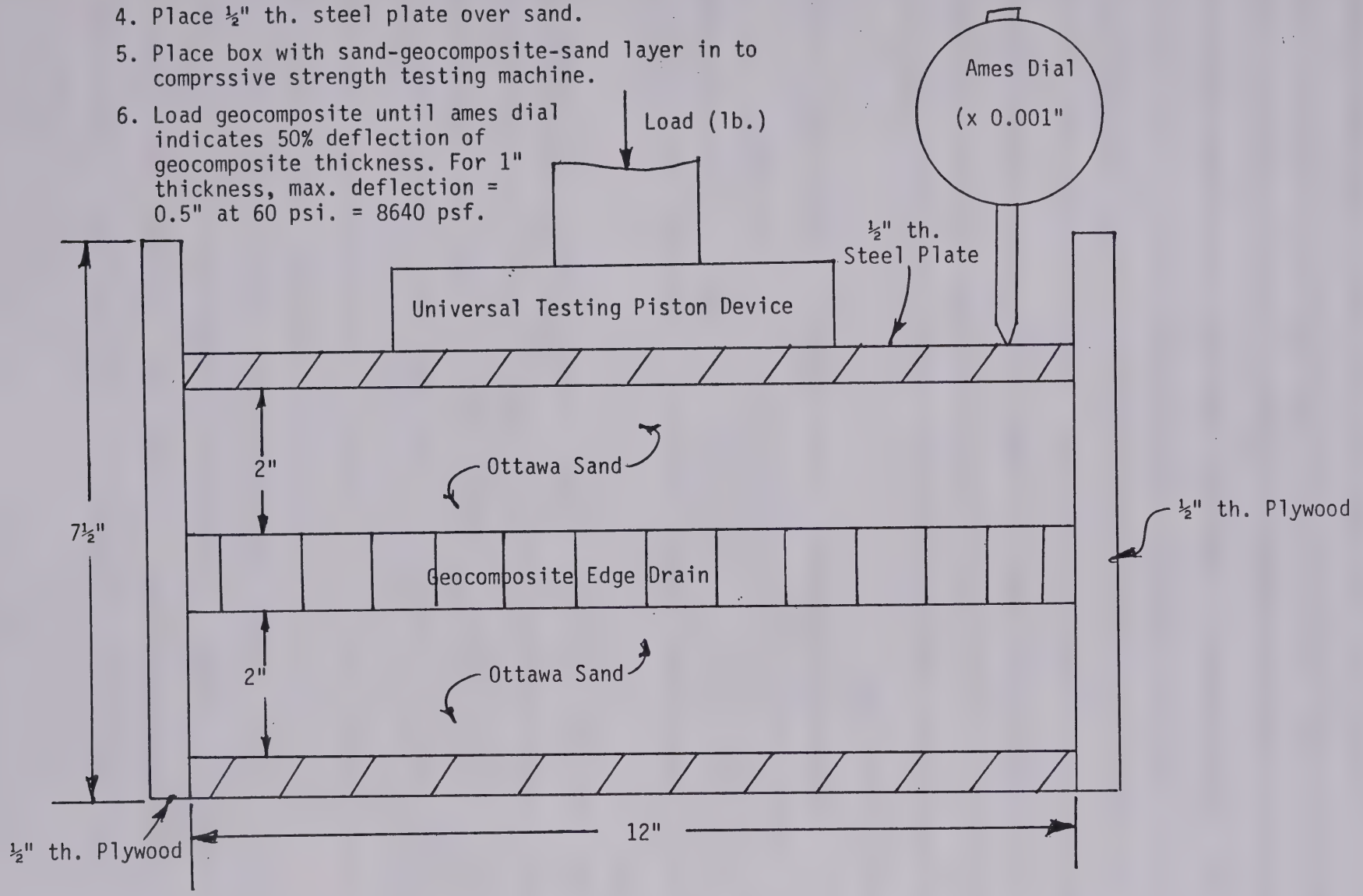
COMPRESSIVE STRENGTH TEST PROCEDURE

1. Place 2" th. layer of Ottawa Sand into box.
2. Place 12" x12" sq. section of geocomposite on to soil.
3. Cover geocomposite with 2" of Ottawa Sand.
4. Place ½" th. steel plate over sand.
5. Place box with sand-geocomposite-sand layer in to comprssive strength testing machine.
6. Load geocomposite until ames dial indicates 50% deflection of geocomposite thickness. For 1" thickness, max. deflection = 0.5" at 60 psi. = 8640 psf.

TEST CRITERIA

Min. Compressive Strength = 60 psi.
@ 50 % deflection of Core.

No tearing or puncturing of fabric.



SECTION - COMPRESSIVE STRENGTH TESTING OF GEOCOMPOSITE EDGE DRAIN MATERIALS

Figure 3

The minimum 1 in. thickness criteria ensures sufficient rigidity of the core during installation and compaction, and also allows for a sufficient hydraulic opening to meet the minimum 600 gph. flow criteria.

4. Filter Fabric - Shall be Non-woven, Equivalent Opening Size (E.O.S.) = No. 70 - 100 U.S. Standard Sieve Size

Non-woven fabric is stronger and more puncture resistant than woven fabric.

The required EOS = No. 70 - 100 is selected according to FHWA Task Force 25 criteria which will effectively prevent passage of NJDOT subbase fines (minus No. 200 sieve particle) through the fabric into the hydraulic opening of the core.

5. Product Dimensions - Drains should be available in standard 12", 18", and 24" widths with roll lengths of 100 ft.minimum.

The product should be available in standard widths to eliminate confusion and promote uniform selection of geocomposite sizes during design.

The material should be shipped in roll lengths of at least 100 ft to allow for ease of installation and minimal splicing between rolls. Sheets should not be permitted. Manufacturers must be capable of supplying compatible splices, connections, and end caps for their material.

III. PRODUCT SELECTION

Six (6) manufacturers submitted geocomposite edgedrain products for evaluation. The manufacturer's product literature was evaluated in accordance with the criteria discussed in Section II and results are summarized in Table 1. Results of the preliminary literature evaluation and product screening indicated that Hydraway, AdvanEdge (ADS), and Akwadrain meet the minimum flow and compressive strength criteria. Based on the preliminary screening, these 3 products were selected for laboratory evaluation and experimental field installation along the northbound shoulder of I-295 at the following locations (Figure 4).

Hydraway	Sta. 644+00 to 666+00	2200 LF
AdvanEdge	Sta. 666+00 to 684+00	1800 LF
Akwadrain	Sta. 684+00 to 704+00	2000 LF
	Total =	6000 LF

The Eljen, Enkadrain, and Miradrain products did not meet the minimum flow and strength criteria and were eliminated from further evaluation on this project.

IV. CONSTRUCTION PLAN DEVELOPMENT

A typical plan detail and construction notes incorporating the experimental edgedrain were prepared and forwarded to NJDOT, Division of Roadway Design, for a change of plans. The change of plans way completed by Design Squad 5 and forwarded to the Region IV Construction Engineer and the I-295, Sec. 3F, 4K, 5K Resident Engineer.

The project contractor was informed of the change order and elected to install the 6000 LF of experimental geocomposite edgedrain on a force account basis (Time, Material, and Profit). The remaining 85,200 LF of Type X Stone Longitudinal Underdrain was installed at the contract bid price of $14.00/LF.

PRODUCT	MANUFACTURER & ADDRESS	FLOW 600 gph (min) 12" width	COMPRESSIVE STRENGTH 60 psi (min)	CORE MATERIAL Polyethylene req'd.	FILTER FABRIC non-woven EOS= 70 max.	DIMENSIONS 12,18,24", Rolls, Splices, etc.	REMARKS
ADVANEDGE	ADS Box 389 Ludlow, Mass. 413-589-0516	600 gph	55.5 psi	High Density Polyethylene	nonwoven, EOS=70, Design prevents fabric intrusion.	12,15,18" width in rolls splices provided	Comp. Strength 55.5 psi vs 60 psi (min) ACCEPT for test
AKWADRAIN	Int'l. Const. Equipment Inc. 301 Warehouse Dr. Matthews, NC 28105 800-438-9281	720 gph	55.5 psi.	Polyethylene	nonwoven, EOS =70-100, Fabric glued to core.	12, 18, 24" wid. in rolls, splices provided	Comp. Strength 55.5 psi vs 60 psi (min) ACCEPT for test
ELJEN	Eljen Corp. 15 Westwood Road Storrs,Conn. 06268 203-429-9486	300 gph	30 psi	Polystyrene	nonwoven, EOS= 70, Fabric not attached to core	12, 18, 24" wid. in rolls, splices provided	FAILS on Flow, Comp. Strength, and core material Not bonded to core
ENKADRAIN	BASF Corp. Fibers Division Enka, N.C. 28728 704-667-7457	480 gph	16 psi	Nylon 6	nonwoven, EOS=70-100, Fabric glued to core	12, 18" widths in rolls, splices provided	FAILS on Flow, Comp. Strength, and core material requirements.
HYDRAWAY	Monsanto Co. 2381 Centerline Dr. St. Louis, Mo. 63146 800-325-4330	790 gph	63 psi	Low Density Polyehylene	nonwoven, EOS= 70-100, Fabric fused to core.	12,18,24" widths in rolls, splices provided	ACCEPT for installation
MIRADRAIN 4000	Mirafi Inc. PO Box 240967 Charlotte, NC 28224 800-438-1855	300 gph	30 psi	Polystyrene	nonwoven, EOS=100 max, Fabric glued to core.	Custom sizes available. in rolls splices provided	FAILS on Flow, Comp. strength, and core material requirements.

Table 1 - Literature Evaluation of Geocomposite Edgedrains for Rte. I295 - Sec. 3F, 4K, 5K

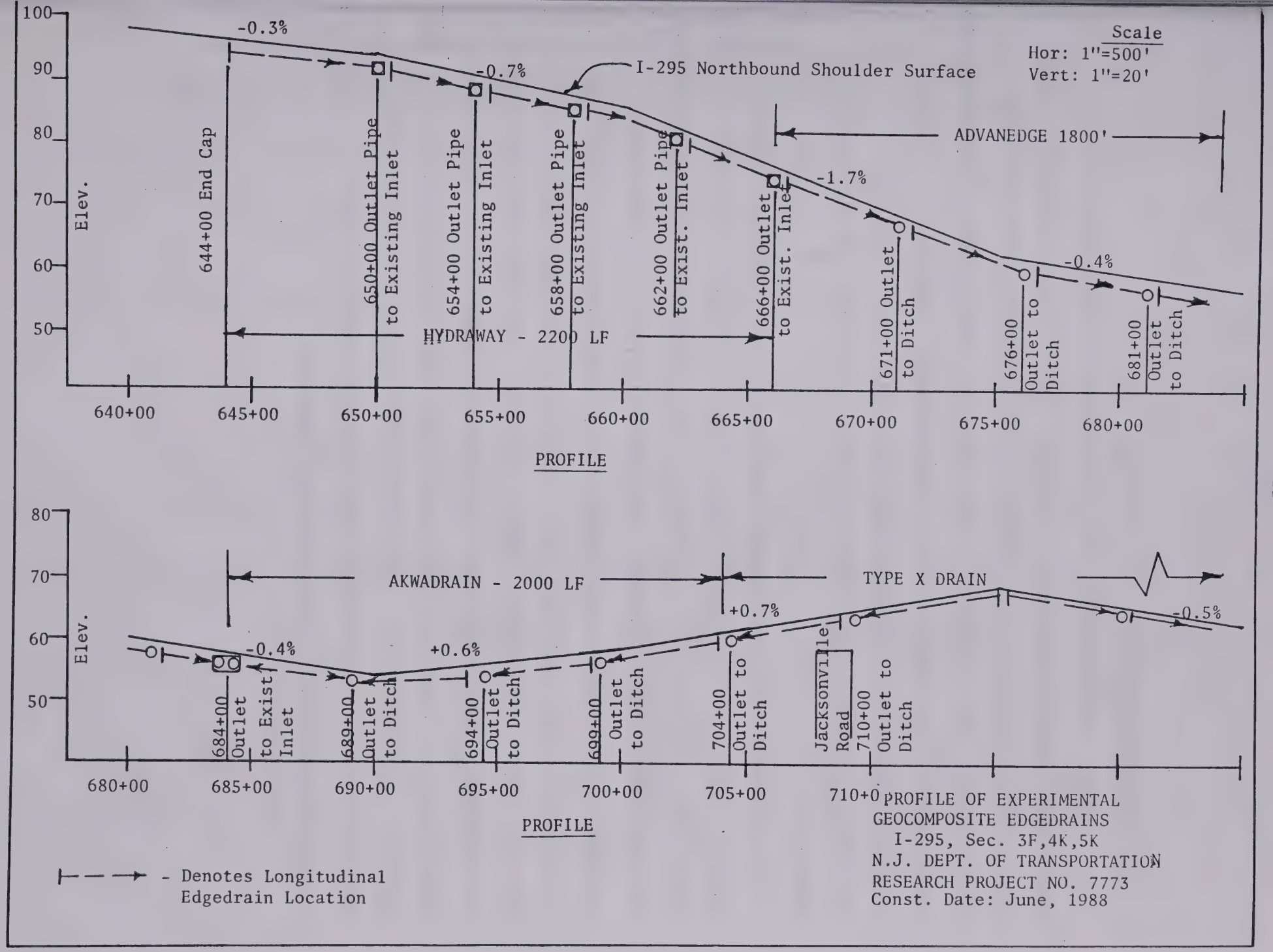


Figure 4 - Location of Geocomposite Edge Drain Rte. I295

V. LABORATORY EVALUATION

1. Flow - Infiltration flow rates of the three experimental geocomposite drains along with a standard Type X stone underdrain were determined through Lysimeter Testing in the Research Laboratory (Photo Appendix #3). The objective of the Lysimeter testing was to determine the infiltration flow capacity of the geocomposites installed in a typical, relatively impermeable NJ gravel subbase and, in turn, compare infiltration rates of the geocomposites to flow rates of the Type X underdrain.

The Lysimeter was constructed according to the drawings shown on Figures 5 and 6 and backfilled with I-3 gravel subbase material (Old 1961 Specification Designation - Type 1B). The subbase material was excavated from the I-295 project so that the permeability of the soil in the lysimeter is identical to permeabilities of the subbase found at the experimental field installation. The subbase was compacted in 6 inch lifts at an optimum moisture content of 10%. Trenches were excavated in the compacted subbase, and the 3 geocomposite edgedrains and the Type X Underdrain were installed. A concrete slab was constructed on top of the compacted subbase and 1/4 inch joints were formed over the edgedrains to simulate the open longitudinal joint commonly found at the P.C.C. mainline pavement-bituminous concrete shoulder interface.

NOTES

1. Construct lysimeter with ½" th. plywood and steel angle corner braces.

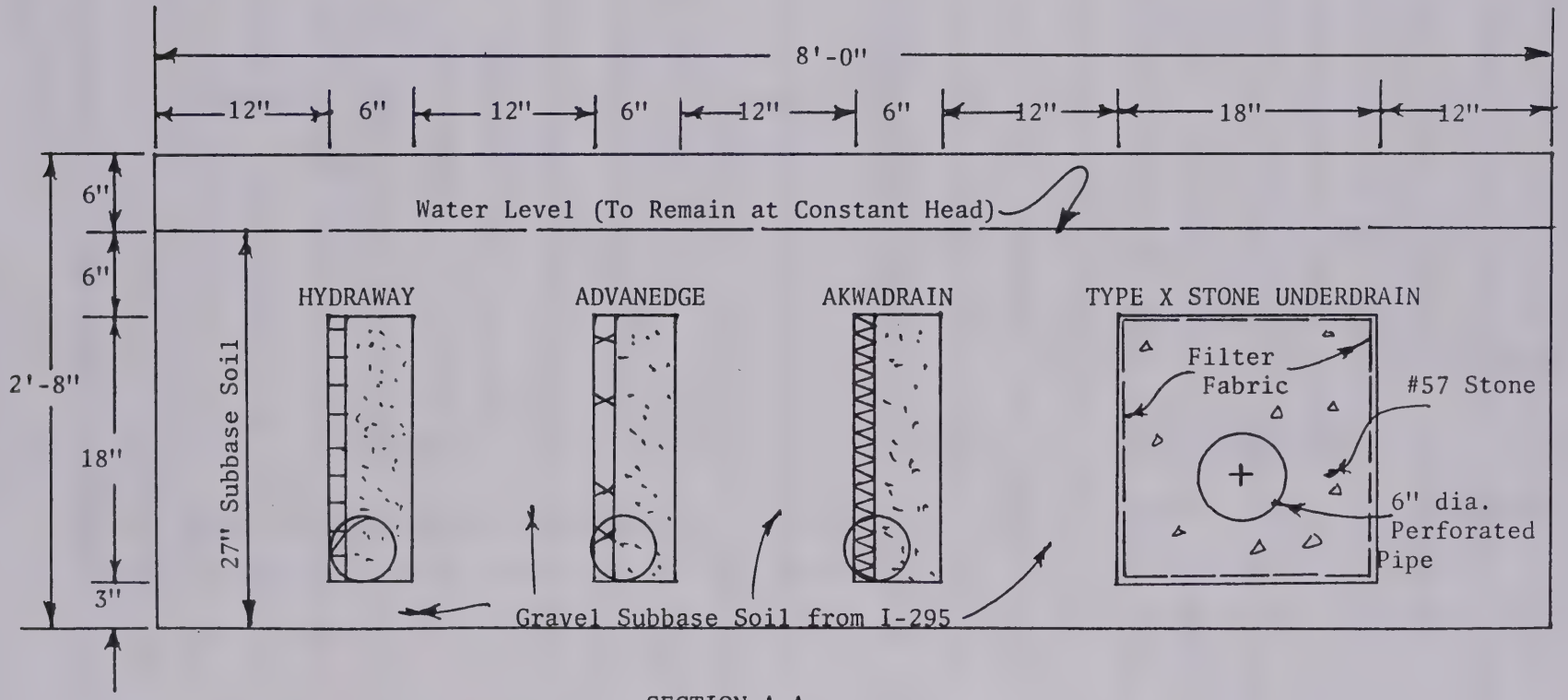
2. Fill lysimeter with I-3 Gravel Subbase soil from I-295 shoulder to 27" depth. Compact gravel in 6" lifts at Optimum Moisture Content = 10% at 95% of maximum proctor density.

3. Excavate trenches for Geocomposite and Type X drains to dimensions shown.

4. Install outlet pipes. Place plugs at outlets. Install Geocomposite and Type X drains. Backfill and compact trenches.

5. Flood cabinet to 27" depth with water. Frreboard shall be 5". Remove plugs from outlets.

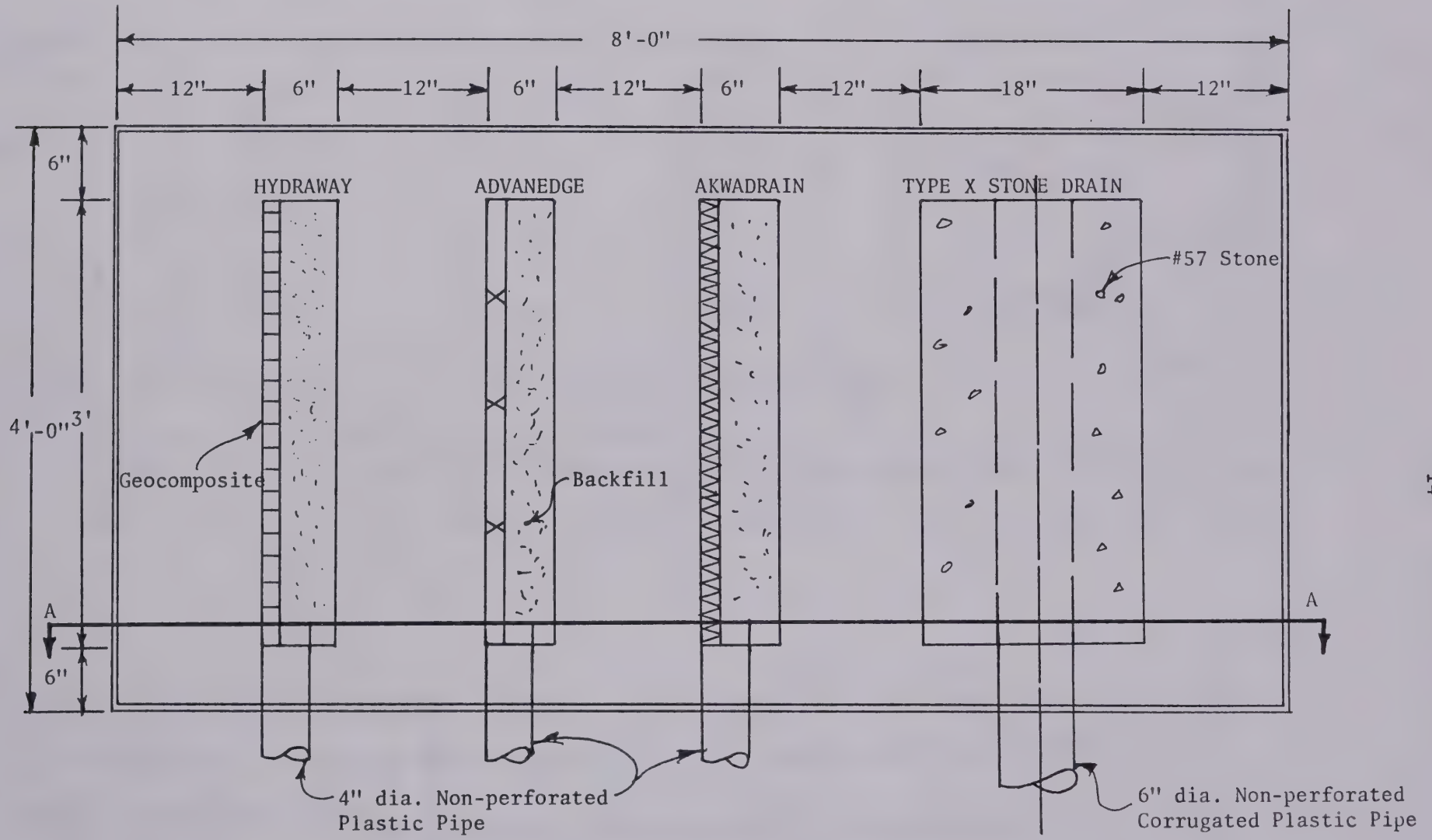
6. Monitor outflow with tipping buckets. Keep water level constant for 1 hour test period.



SECTION A-A
LYSIMETER

Figure 5 - Lysimeter to Test Flow From Edge Drain

Lysimeter cabinet constructed of ½" th. plywood with angle steel braces.
Dimensions of cabinet: L = 8'-0", W = 4'-0", H = 2'-8"



PLAN

LYSIMETER

For Flow Testing of Geocomposite Edgedrains

Figure 6 - Plan View of Lysimeter for Flow Testing of Geocomposite Edgedrain

Infiltration flow testing was conducted by flooding the lysimeter to a level of 24 inches above the invert of the geocomposite drains in order to simulate the hydraulic head found on the I-295 field installation. Outflow was determined for 1 hour periods using tipping buckets and a momentary on-off recorder.

The average results of the lysimeter testing are summarized on Table 2. Although the geocomposites have in-plane flow capacities exceeding 600 gph, the lysimeter testing indicates that the impermeable gravel subbase restricts infiltration to the geocomposites, and outflow from the lysimeter only ranged from 41 to 47 gph. Clearly, the impermeable subbase never allows the geocomposite to reach maximum flow capacity and the permeability of the subbase is the limiting factor when considering flow capacity of these geocomposite drains.

Also, the lysimeter testing indicates that since infiltration is restricted by the impermeable NJ subbase soils, geocomposite edgedrain outflow is similar to Type X stone drain outflow (Geocomposites Flow = 41 - 47 gph vs. Type X Drain Flow = 43 gph). Therefore, geocomposite drains retrofitted in existing concrete pavements should provide sufficient flow capacities similar to the more expensive Type X drains.

2. Compressive Strength - The strength of the 3 experimental geocomposites were determined by loading with a universal testing machine using a 2" thick Ottowa sand bed to simulate soil loading in the field. This method was outlined in Figure 3. Other methods of geocomposite strength testing are conducted using plate loading of the core. However, plate loading does not account for soil loading of the fabric between the nodes of the core and does not account for the deflection of the fabric into the hydraulic opening under loading.

TABLE 2

Geocomposite Longitudinal Edge Drain

NJDOT RESEARCH LABORATORY RESULTS

Test	Required	Hydraway	ADS	AKwadrain	Type X Stone Underdrain
Flow (gph) (Lysimeter)	Similar to Type X Drain Flow	41	42	47	43
Compressive Strength (psi) (at 50% deflection)	60	100	80	200	N/A
Composition	HDPE	HDPE	HDPE	HDPE	N/A
Thickness (in.)	1.0	1.1	1.25	1.1	N/A
Fabric Type	Non-woven	Non-woven	Non-woven	Non-woven	N/A
Encapsulation	*	*	**	*	N/A
E.O.S.	#70-#100 Sieve	#70	#70-#100	#70	N/A
Roll Width (in.)	12, 18, 24	Yes	Yes	Yes	N/A
Roll Length (ft.)	100 min.	400	100	400	N/A

*Fabric Bonded to Core

**Core Design prevents fabric intrusion

Results of the compressive strength testing are shown on Table 2. All 3 products meet the 60 psi min. strength criteria at 50% deflection of the core-fabric interface (1/2" deflection for 1" thick core).

3. Evaluation of Existing Subbase Soils - The existing subbase soils from I-295 were sampled and tested for gradation, permeability, moisture-density relationship, and in-situ moisture content.

a. Gradation - I-3 Subbase (Old 1961 Spec. Designation - Type B)

Sieve	% Passing	Required
2"	100 %	100 %
3/4"	93 %	60 - 100 %
No. 4	73 %	40 - 75 %
No. 50	15 %	5 - 30 %
No. 200	10 % *	0 - 7 %

* Note that the subbase material contains excess fines. This accounts for the relatively low permeability of the subbase along I-295.

b. Permeability = 0.1 to 1.0 ft/day

Determined previously with a constant Head Permeameter during NJDOT Research Study No. 7740.

c. Proctor Moisture - Density

Max Dry Density = 124 pcf.

Optimum Moisture = 10.5 %

d. In-Situ Moisture Content

Moisture contents of subbase sampled in the field range from 10.3 to 11.5%. In comparison the optimum moisture content is 10.5%. Calculations indicate that the subbase is about 80% saturated.

VI. FIELD EVALUATION

In June 1988, the Hydraway, AdvanEdge, and Akwadrain products were installed for field demonstration in approximate 2000 LF test sections along I-295 northbound as shown in Figure 4.

The edge drains were installed by Hess Brothers Construction during June 15 to June 21, 1988. 6000 LF of geocomposite edgedrain was installed in 6 working days.

1. Installation

The existing bituminous concrete shoulder was milled 2" deep to expose the gravel subbase. A 6" wide trench was excavated 27" deep from the pavement surface with a Vermeer Diesel Trencher (Photo Appendix #4 thru #14). After the trench was excavated to a line and grade parallel to the existing pavement surface, the geocomposite mat was unrolled along the pavement and placed upright in the trench by hand. Additional rolls were spliced together by hand. The top 2" to 3" of the 18" wide geocomposite mat was held against the lower edge of the concrete pavement with a shovel while the first lift of backfill was placed back into the trench. The first lift was compacted with a modified ski-foot plate compactor pulled by a chain attached to a motor grader. The second and final lift of back fill was pushed into the trench using a motor grader blade and compacted.

The outlet pipes were constructed at 500 ft. intervals and tied into existing catch basins at cut sections or daylighted to sideslope ditches at fill sections. Outlet trenches were excavated using a backhoe. The 4" dia. rigid PVC Plastic Outlet Pipes were placed in the trench at a minimum -0.5% slope and tied to the geocomposite mat using fittings and 90-degree tee sections. The outlet trench was compacted with a vibratory plate compactor.

A few months later, 4 inches of the existing gravel subbase was removed and a new 6" thick Bituminous Concrete Shoulder was constructed to complete the installation of the experimental geocomposite edgedrains.

2. Outflow Measurements

Since the test section has received a new bituminous concrete shoulder and the mainline P.C.C. pavement joints have been cleaned and resealed, the pavement surface should be relatively water-tight and little subsurface flow from the geocomposite drains can be expected. However, preliminary bucket and stopwatch outflow measurements indicate that the geocomposite drains are removing water from the pavement sections in amounts equal to flows from the Type X stone drains installed in other areas of the project (Table 3).

A rain gauge and outflow tipping buckets were installed during the summer of 1990 in order to provide more conclusive flow results. This information will be presented in follow up reports.

3. Faulting & Pumping Survey

Average preconstruction, transverse joint faulting measurements of the concrete mainline pavement ranged from 0.17" (3/16") to 0.25" (1/4") with and average of 0.20".

Post construction faulting measurements indicate that faulting along the geocomposite edge drain sections have remained indentical to the preconstruction readings. This is to be expected because the contract did not specify grinding as a means to remove the faults. However, the geocomposite drain installation can be expected to halt the rate of faulting in the coming years. Future measurements will be conducted annually to track any decrease in the faulting rate.

TABLE 3

Geocomposite Longitudinal Edge Drain

Preliminary Outflow Results

Route I-295, Sec. 3F, 4K, 5K NB

Installation Date - June, 1988

Rainstorm Date	Station	Edgedrain	Flow (gph)
7/21/88	671 + 00	ADS	9
"	689 + 00	Akwadrain	2
"	694 + 00	"	42
"	699 + 00	"	52
"	710 + 00	Type X Stone	5
8/17/88	671 + 00	ADS	10
"	694 + 00	Akwadrain	16
"	710 + 00	Type X	8
10/24/88	671 + 00	ADS	15
"	689 + 00	Akwadrain	3
"	694 + 00	"	24
"	699 + 00	"	30
"	710 + 00	Type X	7
2/15/89	671 + 00	ADS	133
"	689 + 00	Akwadrain	24
"	699 + 00	"	112
"	710 + 00	Type X	15

NOTE: Rough flow measurements conducted with stopwatch and calibrated bucket. In most cases, geocomposite edge drain flows equal or exceed type X Underdrain flows.

Prior to reconstruction, the existing mainline concrete pavement pumped heavily in the areas adjacent to the transverse expansion joints. The pumping was characterized by staining of the shoulder with fines ejected from beneath the concrete pavement slab and subsequent erosion and deterioration of the bituminous concrete shoulder adjacent to the transverse joints. However, the construction of the 6" thick bituminous concrete shoulder along with the installation of geocomposite edgedrain has halted the pumping completely. Surveys will be conducted semiannually to determine if the experimental edgedrains can fully prevent pumping in future years.

VII. COST ANALYSIS

Recent cost figures provided by the contractor indicate that the geocomposite drains were installed for $6.00 per LF. In comparison, the Type X Underdrain contract bid price is $14.00 per LF. The geocomposite drain costs were calculated on a force account basis (time, materials, and profit) and include the use of manual installation methods by a contractor who was unfamiliar with the construction of these new products (see Appendix B). As contractors gain more experience with mechanized placement of these geocomposite drains, future bid prices of $3.00 to $4.00 per LF are likely.

It is obvious that the use of geocomposite drains can result in significant cost savings when compared to current prices for Type X stone underdrains. For instance, if the geocomposite drains were used in lieu of Type X drains on Route I-295, Sec. 3F,4K,5K with an underdrain quantity of 17.3 mile or 91,200 LF, the total potential savings would be $8.00 x 91,200 LF = $729,600 or 3/4 million dollars!

Since the geocomposite edgedrains have been in place along I-295 for only about two years, long-term field performance data is not available in order to make concise life-cycle cost projections. However, one way to quantify the potential economic benefits to geocomposite edgedrains is to determine the breakeven point of how long geocomposite drain installation must prolong the life of a rehabilitated or resurfaced pavement in order to justify the original geocomposite cost of $6.00 per LF.

Consider the following breakeven analysis for a typical 4-lane, divided portland cement concrete highway in New Jersey.

Given : Major Reconstruction Cost = $800,000/mile
(Source : Memo from R. Weed to K.Afferton, Resurfacing Needs, 7/14/88)

Geocomposite Cost = $64,000/mile (@ $6.00 per LF)

$$\text{Added Cost due to Geocomposite Edgedrains} = \frac{\$\ 64,000}{\$800,000} = 8\%$$

Strategy #1 - Reconstruction Only

Present Worth (PW) = $800,000

Interest (i) = 8%

Rehab. Pavement Life w/o Drainage (n) =? (Assume range from 6 to 12 years)

n (yrs)	PW ($)	EUAC* Factor	EUAC ($/year)
6	800,000	0.21632	173,000
8	"	0.17401	139,000
10	"	0.14903	119,000
12	"	0.13270	106,000

Strategy #2 - Reconstruction + Geocomposite Drain

Present Worth (PW1) = 800,000 + 64,000 = $864,000

Rehab. Pavement Life w/o Drainage (n) = ? (Assume range from 6 to 12 years)

Breakeven Rehab. Pav't Life with Drainage (n1) = ?

Breakeven Equivalent Uniform Annual Cost Factor of Rehab with

Drainage (EUAC1) = $\frac{\text{EUAC}}{864,000}$

n (yrs)	PW1 ($)	EUAC Factor	EUAC1 Factor	n1
6	864,000	0.21632	0.200	6.5
8	"	0.17401	0.161	9.0
10	"	0.14903	0.138	11.5
12	"	0.13270	0.123	13.5

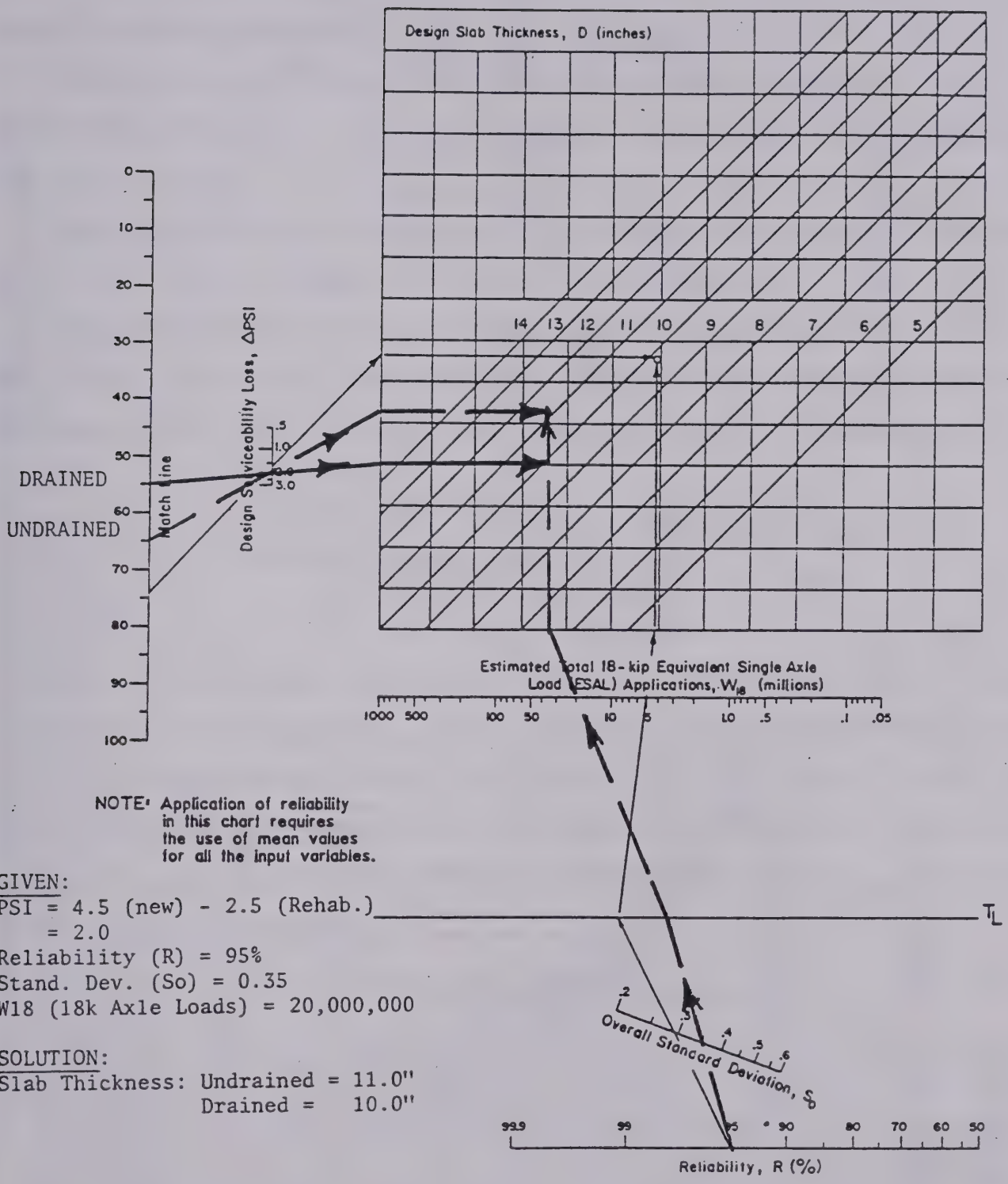
*Equivalent Uniform Annual Costs

The preceding analysis indicates that for a 4 lane concrete highway, the price of geocomposite edgedrain installation will only be 8% of the major reconstruction cost. Also, edgedrains will have to prolong the rehabilitated pavement life at the most by only 1.5 years in order to justify the original cost of edgedrain construction. Clearly, the 1.5 year additional life breakeven point means that the initial costs of edgedrain installation are small in comparison to the expected benefits from prolonged pavement life.

A similar analysis was conducted for 2 lane and 6 lane concrete pavements. The results indicate that the required additional life breakeven point ranges from 1.0 year for 6 lane pavements to 3.5 years for 2 lane pavements.

	2 Lane	4 Lane	6 Lane
Rehab. Cost	$400,000	$800,000	$1,200,000
Geocomposite Cost	$ 56,000	$ 56,000	$ 56,000
Rehab + Drainage	$456,000	$856,000	$1,256,000
% Added Cost	16%	8%	5%
Assumed Rehab Life	12 yr.	12 yr.	12 yr.
Breakeven Rehab Life with Drainage	15.5 yr.	13.5 yr.	13 yr.
Required Breakeven Added Life	3.5 yr.	1.5 yr.	1 yr.

In an attempt to further quantify the potential cost savings of retrofitting existing concrete pavements with geocomposite edgedrains, an analysis can be conducted using the rigid pavement thickness design procedure outlined in the "1986 AASHTO Guide for Design of Pavement Structures." (See Figures 7 and 8.)


Design Slab Thickness, D (inches)
14 13 12 11 10 9 8 7 6 5
Design Serviceability Loss, ΔPSI
.5
1.0
2.0
3.0
DRAINED
UNDRAINED
Match Line
Estimated Total 18-kip Equivalent Single Axle Load (ESAL) Applications, W_{18} (millions)
1000 500 100 50 10 5 1.0 .5 .1 .05
T_L
Overall Standard Deviation, S_o
.2 .3 .4 .5 .6
99.9 99 95 90 80 70 60 50
Reliability, R (%)

NOTE: Application of reliability in this chart requires the use of mean values for all the input variables.

GIVEN:

PSI = 4.5 (new) - 2.5 (Rehab.)
= 2.0
Reliability (R) = 95%
Stand. Dev. (So) = 0.35
W18 (18k Axle Loads) = 20,000,000

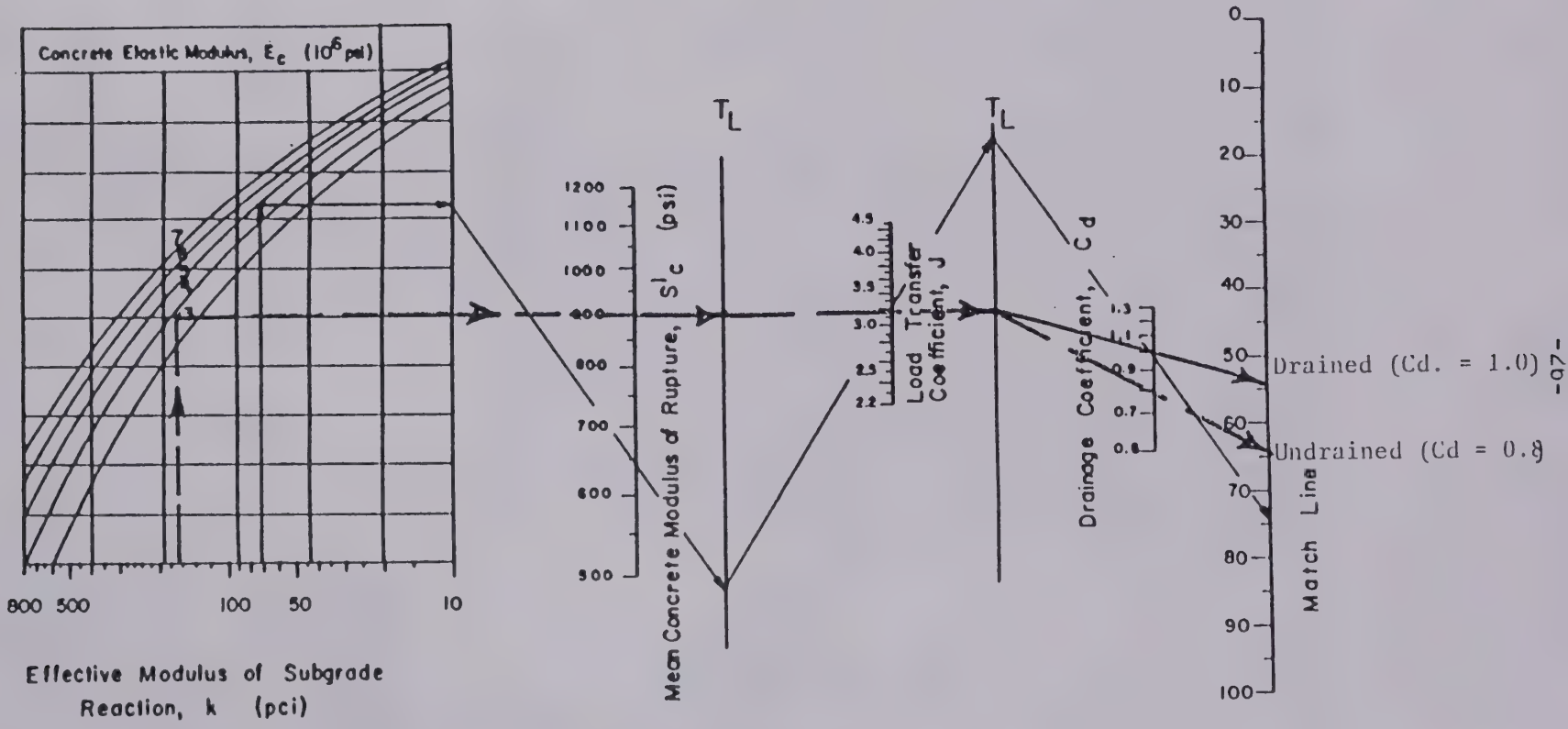
SOLUTION:

Slab Thickness: Undrained = 11.0"
Drained = 10.0"

Figure 7 **Design chart for rigid pavements based on using mean values for each input variable**

NOMOGRAPH SOLVES:

$$\log_{10} W_{18} = Z_R * S_o + 7.35 * \log_{10}(D+1) - 0.06 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.5 - 1.5}\right]}{1 + \frac{1.624 * 10^7}{(D+1)^{8.46}}} + (4.22 - 0.32 p_t) * \log_{10}\left[\frac{S_c' * C_d \left[D^{0.75} - 1.132\right]}{215.63 * J \left[D^{0.75} - \frac{18.42}{(E_c/k)^{0.25}}\right]}\right]$$


Concrete Elastic Modulus, E_c (10^6 psi)
800 500 100 50 10
Effective Modulus of Subgrade Reaction, k (pci)
T_L
1200 1100 1000 900 800 700 600 500
Mean Concrete Modulus of Rupture, S'_c (psi)
T_L
4.5 4.0 3.5 3.0 2.5 2.2
Load Transfer Coefficient, J
Drainage Coefficient, C_d
1.3 0.9 0.7 0.6
0 10 20 30 40 50 60 70 80 90 100
Match Line
Drained (Cd. = 1.0)
Undrained (Cd = 0.8)

GIVEN:
Modulus of Subgrade Reaction (k) = 170 pci.
Concrete Elastic Modulus (Ec) = 4,000,000 psi.
Concrete Modulus of Rupture (S'c) = 900 psi.
Load Transfer Coefficient = 3.2 (Asphalt Shoulder, JRCP)
Drainage Coefficient (Cd): Undrained Condition w/o Edgedrain
= 0.80 (poor drainage)

Figure 8 Design chart for rigid pavement based on using mean values for each input variable

Drained Condition with Edgedrain
= 1.0 (good drainage)

The AASHTO rigid pavement analysis accounts for the benefits of subbase drainage through the use of a Drainage Coefficient (Cd).

The Cd for an existing, undrained NJDOT concrete pavement with impermeable subbase is 0.8 (Poor Drainage, pavement saturated for more than 25% of year).

The installation of geocomposite edgedrains is expected to improve the Cd to 1.0 (Good Drainage).

The design chart for rigid pavements for the undrained (Cd = 0.8) and the drained (Cd = 1.0) condition indicates that the pavements could be designed fully 1 inch thinner with the installation of edgedrains.

	Undrained	Drained (w/Geocomposite)
Cd	0.8 (Poor)	1.0 (Good)
Thickness	11.0 "	10.0 "

At a concrete price of $60.00 per cu.yd., the savings due to a 1" reduction in thickness for a 6 lane highway is approximately $72,000 per mile. Geocomposite edgedrain installation, in addition to halting the rate of faulting and pumping, has the same effect in theory as increasing the structural capacity of concrete pavements in amounts equal to at least 1" of pavement thickness.

VIII. RECOMMENDATIONS

While we are currently finishing only the second year of a five-year evaluation program, the potential cost savings and promising laboratory and field performance indicate that the Department should proceed with specifying Geocomposite Longitudinal Edge Drains as an alternative to Type X underdrains for retrofitting of existing portland cement concrete pavements during CPR and major resurfacing projects.

Type X drains should continue to be solely specified for new concrete pavement construction projects. The open graded drainage layers specified as base course under new concrete pavements provide significant flows to the longitudinal drains. The capacity of the 6" dia. perforated pipe in the Type X drain is required to convey these flows from the pavement structure.

Appendix C contains a suggested specification and typical plan detail for Geocomposite Longitudinal Edge Drains. A product-generic based specification was chosen to allow the contractor to select a prequalified product with minimal materials testing by Department forces.

IX. DESIGN GUIDELINES

Geocomposite edgedrains should be specified to improve subbase drainage along existing concrete pavements during selected Concrete Pavement Rehabilitation (CPR), Bituminous Concrete Overlay, Shoulder Rehabilitation, and Maintenance projects. Geocomposite edgedrains should be installed along existing concrete pavements that suffer from pumping and faulting in accordance with the following criteria.

Pumping - Candidate Concrete Pavements should exhibit more than 5% of slabs pumping over length of project. Evidence of pumping includes ejection of fines and resulting "stains" on shoulder after rainfall or erosion and deterioration of bituminous concrete shoulder in areas adjacent to transverse joints, and or;

Faulting - Candidate Concrete Pavements should exhibit more than 1/4" faulting (taken as average) over length of project.

Geocomposite edgedrains should be installed on the following types of projects on pavements which meet the minimum pumping and faulting criteria:

1. CPR Projects: Edgedrains should be installed after full depth concrete slab replacement and slab subsealing operations but prior to placement of a new shoulder surface course.

2. Bituminous Concrete Overlay of Existing Concrete Pavement: Edgedrains should be constructed prior to overlay.

3. Shoulder Rehabilitation: Edgedrains should be installed along shoulders that exhibit drainage related distress such as alligator cracking or longitudinal faulting of the mainline pavement-bituminous concrete shoulder joint.

4. Maintenance Uses: Geocomposite edgedrain construction methods are such that the drains can be routinely installed by NJDOT Maintenance forces using available equipment. Trenches can be excavated with Department owned backhoes or rented trenchers. The edgedrain can be installed by hand and trenches can be compacted using a modified vibratory plate compactor. Geocomposite edgedrain projects can be selected by maintenance engineers in accordance with the criteria discussed above.

APPENDIX A

Calculations for Selection of Geocomposite Edge Drains

FORM DC-30
REV. 1/9/67

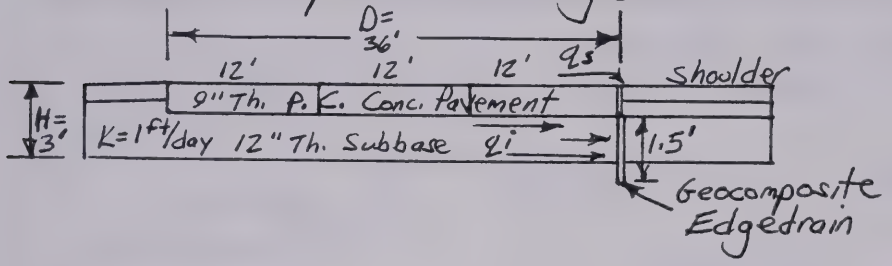
NEW JERSEY DEPARTMENT OF TRANSPORTATION

SHEET NO.___OF___

ROUTE (1927)_____ 1953_____ SECTION_____ PROJECT I-295, Sec 3F, 4K, 5K

MADE BY J. Kauffman DATE_____ CHECKED BY_____ DATE_____

SUBJECT Determine Required Flow Capacity of Geocomposite Edge Drain F.A. NO._____



Assume Max. Outlet Spacing = 500 ft.

① Flow Through Subbase

$q_i = (K)(i)(A)$

where: q_i = Flow through subbase (cu.ft/day)

K = subbase permeability = 1 ft/day

i = hydraulic gradient (ft/ft)

$= H/D = 3'/36'$

$= 0.083$ ft/ft

A = Geocomposite Cross-Section Area for 500 LF Spacing

$= 1.5' \times 500' = 750$ ft²

$q_i = (1 \text{ ft/day})(0.083)(750)$

$= 62.25$ cu.ft/day

$q_i \cong$ 20 gal/hr

② Flow Through Concrete Pavement - Shoulder Joint

$q_s = (I_c)(500 \text{ LF})$

where: I_c = Longitudinal Joint Infiltration Rate = 2.4 cu.ft/day/L.F.

(Source: Highway Subdrainage Design, FHWA-TS-80-224, August, 1980)

$q_s = (2.4)(500 \text{ LF})$

$q_s = 1200$ cu.ft/day

$q_s \cong$ 375 gal/hr.

Total In-Flow $= q_i + q_s = 30 + 375$

$=$ 395 gph

Use F.S. = 1.5 to allow for Fabric Plugging. Design Flow = 1.5(395)

$\cong$ 600 gph min.

FORM DC-30
REV. 1/9/67

NEW JERSEY DEPARTMENT OF TRANSPORTATION

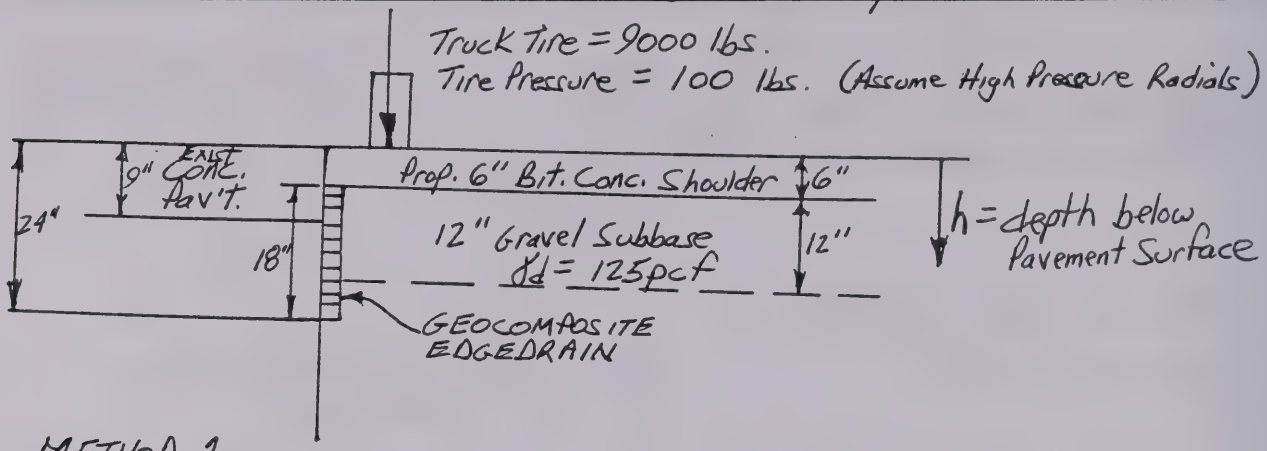
SHEET NO.___ OF___

ROUTE (1927)_____ 1953_____ SECTION_____ PROJECT I-295, Sec. 3F, 4K, 5K

MADE BY J. Kauffman DATE 3/4/88 CHECKED BY_____ DATE_____

SUBJECT Research Project No. 7773 F.A. NO._____

Determine Lateral Force on Geocomposite Fin Drain



METHOD 1

Rankine Formula (p. 333 "Foundation Analysis and Design")
$\gamma = 125$ pcf., $K_1 = 0.307$, neglect stability of Bit. conc. shoulder.

$h = 0$ Lat. Force $= \left(100 \frac{lb}{ft^2}\right)\left(\frac{144 in^2}{ft^2}\right)(0.307) =$ 4420 psf = (30 psi)

$h = 1$ ft $= (1ft)(0.307)(125 lb/ft^2) + 4420$ psf $=$ ~~4460~~ 4458 psf = (31 psi)

$h = 2$ ft $= (2ft)(0.307)(125 lb/ft^2) + 4420 =$ 4496 psf = (31.2 psi)

METHOD 2

From p. 356, "Foundation Analysis and Design"

Lateral Pressure $(\sigma_h) = \frac{0.28V}{H^2}\left(\frac{n^2}{(0.16+n^2)^3}\right)$ where $V = 9000$ lb, $H = 2$ ft

$n = \frac{0.5'}{2}, \frac{1.0'}{2}, \frac{1.5'}{2}, \frac{2.0'}{2}$

$h = 0.5'$: $\sigma_h = \frac{0.28(9000)}{(2)^2}\left(\frac{\left(\frac{0.5}{2}\right)^2}{\left(0.16+\left(\frac{0.5}{2}\right)^2\right)^3}\right) = 3579$ psf. = (24.8 psi)

$h = 1.0'$: $\sigma_h = 2283$ psf. = (15.8 psi)

$h = 1.5'$: $\sigma_h = 939$ psf = (6.5 psi)

$h = 2.0'$: $\sigma_h = 404$ psf = (2.8 psi)

CONCLUSION

Max. Pressure = 31.2 psi determined from Method 1, Rankine Formula.
Use Max. Allowable Pressure = $2(31.2) \approx 60$ psi for design.

APPENDIX B

Construction Costs for Geocomposite Edge Drains

B-1

INVOICE

AREA CODE 201
721-1500

HESS BROTHERS, INC.

CONTRACTORS & ENGINEERS

P. O. BOX 198 PARLIN, NEW JERSEY 08859

TO

NJ Dept. of Transportation
1035 Parkway Ave
Trenton, NJ 08625

Date 2-14-89

Invoice No. 5206 (Revised)

Terms: Re: Hess Job #87-12-11
Proj: Rte. 295, 3F, 4K & 5K
Experimantal Underdrain

To charge you for labor & services on the above noted project to install underdrain per your instructions, period from 6.15.88 to 6/22/88.

Labor				
172	Foreman	48 hrs. X 15.15	727.20	
	Laborer	224.5 hrs. X 14.45	3,244.03	
825	Grader Oper.	16 hrs. X 21.13	338.08	
	Backhoe Oper.	5 hrs. X 22.72	113.60	
				4,422.91
Labor Benefits Cost				
Local 172		272.5 hrs. X 4.60	1,253.50	
Local 825		21 hrs. X 9.25	194.25	
				1,447.75
Labor Additives				
Workman's Comp		.0734		
P.L. & P.D.		.32781		
F.I.C.A.		.0751		
F.U.I.		.008		
S.U.I.		.0605		
		.54481 X 4,422.91		2,409.65
Material				
Monsanto		Inv.# 75-40292	7,194.20	
		Cr.# 76-14175	(6,703.20)	
		Inv.# 75-41832	4,560.00	
Zoubek		Inv.#122626	4,016.00	
A.H. Harris		Inv.#417076	4,614.00	
Lincoln Supply		Inv.#368819	68.95	
				13,749.95 ✓
Overhead & Profit				
15% Overhead on Labor & Material			2,725.93	
10% Profit on Labor & Material			1,817.29	
				4,543.22 ✓

RECEIVED

MAR 21 1989

N.J. DEPT. OF TRANSPORTATION
FIELD OFFICE - REGION #4

EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER

B-2

INVOICE

AREA CODE 201
721.1500

HESS BROTHERS, INC.

CONTRACTORS & ENGINEERS

P. O. BOX 198 PARLIN, NEW JERSEY 08859

TO

NJ Dept. of Transportation
1035 Parkway Ave
Trenton, NJ 08625

Date 2-14-89

Invoice No. 5206 (Revised)

Terms: Re: Hess Job #87-12-11
Proj: Rte.295, 3F 4K & 5K
Experimental Underdrain

Equipment Rental			
Carbide Sawing, Inc. Vermeer		8,194.50	8,194.50
Equipment			
L-20 Pickup	42 hrs. X 6.10	256.20	
#322 Cat 14 Grader	16 hrs. X 62.34	997.44	
Plate Tamper	40 hrs. X 1.30	52.00	
#266 JCB Backhoe	5 hrs. X 18.76	93.80	
			1,399.44
Total Amount Due This Invoice			$36,167.42

/bej/jr
3-14-89

RECEIVED

MAR 21 1989

N.J. DEPT. OF TRANSPORTATION
FIELD OFFICE - REGION #4

EQUAL OPPORTUNITY

APPENDIX C

Geocomposite Edge Drain Specifications

SECTION 601 - UNDERDRAINS

Geocomposite Longitudinal Edge Drain

DESCRIPTION

This work shall consist of furnishing, installing and backfilling prefabricated geocomposite longitudinal edge drain mat, fittings, outlet piping, and miscellaneous appurtenances as shown on the plans and described in the specifications.

MATERIALS

(a) Prefabricated geocomposite longitudinal edge drain mat shall consist of a flexible, hollow, high density polyethylene core encased in a non-woven filter fabric and be selected from one of the pre-approved manufacturers as listed below:

1. AdvanEdge

   Advanced Drainage Systems
   Stoney Brook Industrial ARea
   Box 389
   Ludlow, MA 01056
   (413) 589-0515

2. AKwadrain

   International Construction Equipment Inc.
   301 Warehouse Drive
   Matthews, NC 28105
   (800) 438-9281

3. Hydraway 1000 and Hydraway 2000

   Monsanto Co.
   2381 Centerline Industrial Drive
   St. Louis, MO 63146
   (800) 325-4330

4. Stripdrain 100 and Stripdrain 80

   Contect Construction Products
   Fonton Street
   Palmer, MA 01069

5. PDS-30

   Prodrain Systems
   1500 Alloy Parkway
   Hyland, Michigan

An approved equal may be selected as an alternate to the products listed above provided that the approved equal meets the following criteria:

Property	Value
Core:	
Composition	High Density Polyethylene
Thickness	1.0 in. (min.)
Flow Capacity (In-plane flow)	300 gal./hr./ft. width (min.) at 1.0% slope (ASTM 4716)
Compressive Strength (50% max. deflection)	60 psi (min.)
Filter Fabric:	
Type	Non-woven
Encapsulation	Fabric shall be bonded to each node of core, or core construction shall prevent intrusion of fabric into hydraulic opening during compressive strength testing.
E.O.S.	#70 - #100 U.S. Standard Sieve Size
Roll Dimensions:	
Width	12", 18" and 24"
Length	100 ft. (min.)

(b) Splices, outlet fittings, end caps, and couplings shall be commercially available products and be supplied by the selected geocomposite edge drain manufacturer.

(c) Non-perforated plastic pipe for edge drain outlets shall consist of 4" diameter schedule 40 PVC pipe or 4" diameter flexible, corrugated plastic outlet pipe. Plastic outlet pipe, required couplings, and 45° and 90° elbow sections shall be supplied by the contractor.

(d) Riprap or concrete outflow structures shall be constructed in accordance with the plans and specifications.

(e) Outflow structure delineators shall consist of a 1-15/32" by 3-1/16" steel "U" posts coated with galvanized steel, nominal weight = x lb/ft. The steelpost shall be 7 ft. long and be provided with a Type 1, single, white, reflector.

(f) Rodent screens shall be constructed in accordance with the plans and specifications.

CONSTRUCTION

GENERAL

At least two weeks prior to beginning installation, the contractor shall furnish the Engineer with copies of the manufacturer's literature with details, specifications, and installation requirements for edge drain mat and outlet pipe. The Contractor shall provide information on the proposed trenching equipment and procedure for edge drain and outlet installation.

A manufacturer's representative shall be required on the project for consultation with the Engineer for the first 3 days of installation and at other times when requested by the Engineer, should problems occur.

Installation of edge drain mat and outlets, and excavation and backfilling of trenches shall be in accordance with the details shown on the plans, as specified herein, and in accordance with the manufactuer's recommendations.

Outlet fittings for transition from the edge drain mat to the 4" diameter outlet pipe shall be installed in accordance with the manufacturer's recommendations.

EXCAVATION

Trenches for the geocomposite edge drain mat shall be excavated with a mechanical trencher or backhoe. Trench location and depth shall be as shown on the plans. Trench width shall be 4 in. minimum to 12" maximum.

INSTALLATION

The edge drain mat shall be placed against the concrete pavement side of the trench and held firmly in place while trench is backfilled in lifts not exceeding 9 inches. Each lift shall be compacted with a standard, 5 hp., vibrating plate compactor outfitted with a modified ski foot attachment. The final lift shall be compacted with a vibratory roller.

Edgedrain mat lengths shall be spliced together prior to installation in accordance with the manufacturer's literature.

Excavation of the trench, placement of the mat, and placement of the first lift of backfill shall be accomplished in a single, continuous operation.

Trenches for outlet pipes shall be excavated to the lines and grades shown on the plans. Plastic outlet pipes shall be placed on the bottom of the trench. Backfill shall be done with existing materials excavated from the trench and thoroughly compacted to 95% of maximum proctor density in lifts not to exceed 6 inches. Backfill materials shall not contain any debris or pavement pieces larger than 2 inches in diameter.

Outlet pipes shall be constructed at a maximum spacing of 500 ft. Outlet pipes shall be tied into existing storm water inlets or daylighted to sideslope ditches in accordance with the plans. Outlet pipe slope shall be -1.0% minimum.

Outlet pipe fittings and couplings shall be installed in accordance with the manufacturer's literature.

All trenches shall be backfilled within 1 hour of edge drain mat or outlet pipe installation.

COMPENSATION

METHOD OF MEASUREMENT

Completed and accepted Geocomposite Longitudinal Edge Drain Mat shall be measured along the centerline of the installed edge drain by the linear foot. Price of edge drain mat shall include all splices, couplings, and fittings as required.

Completed and accepted 4 inch Diameter Plastic Outlet Pipe shall be measured along the centerline of the installed pipe by the linear foot. Price for outlet pipe shall include couplings, elbow sections, riprap or concrete outflow structures, delineator markers, and rodent screens as required.

BASIS OF PAYMENT

The accepted quantities of Geocomposite Longitudinal Edge Drain Mat and 4 inch Diameter Outlet Pipe shall be paid for at a contract unit price as follows:

PAY ITEM	UNIT
Geocomposite Longitudinal Edge Drain	Linear Foot
4" Diameter Plastic Outlet Pipe	Linear Foot

APPENDIX D

Photo Appendix

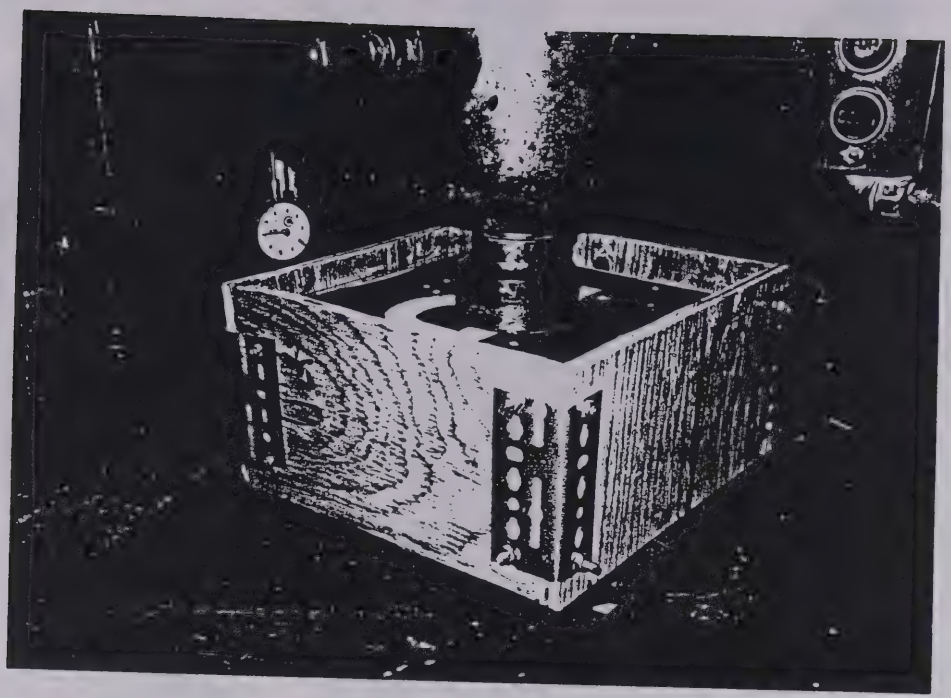


Photo No. 1. Compressive Strength Testing of Geocomposite Edgedrain
Note Ames Dial for determining deflection under loading.

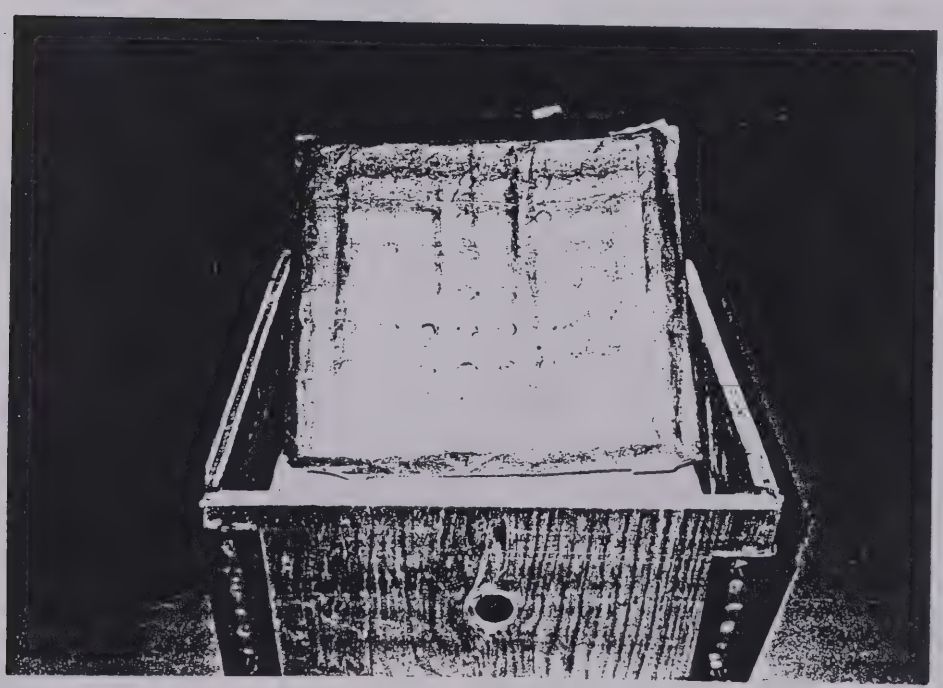


Photo No. 2. Compressive Strength Testing of Geocomposite Edgedrains.

Photo No. 3. Lysimeter for Laboratory Flow Testing of Geocomposite Edge Drain Products. Note three 4" PVC outlet pipes for geocomposite drains and single 6" corrugated plastic pipe for Type X stone drain.

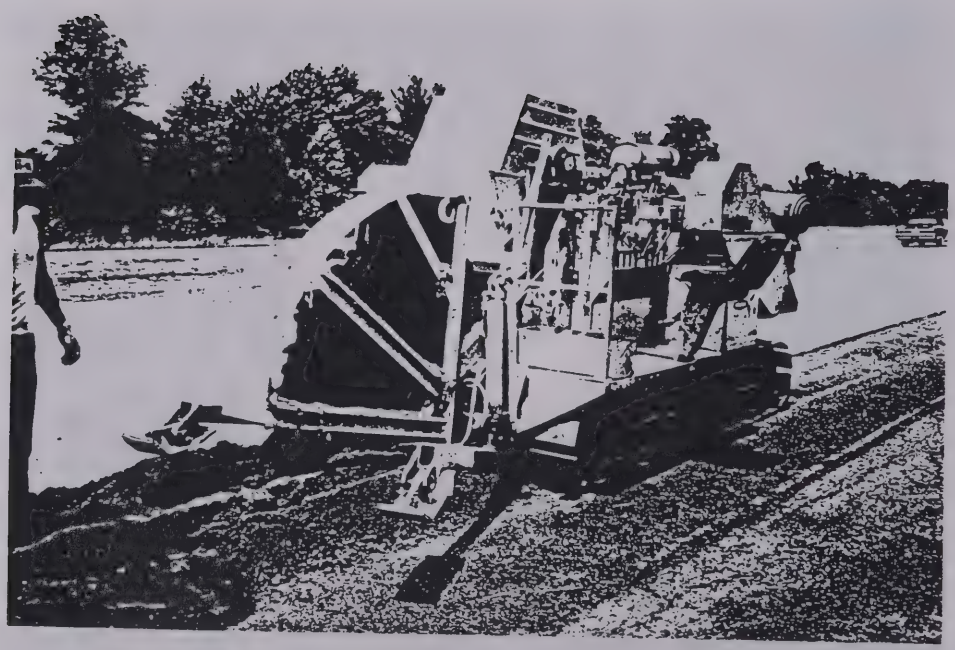


Photo No. 4. Route I-295, Sec. 3F, 4K, 5K. June, 1988 Excavation of 6" wide trench with vermeer saw for geocomposite edge drain.

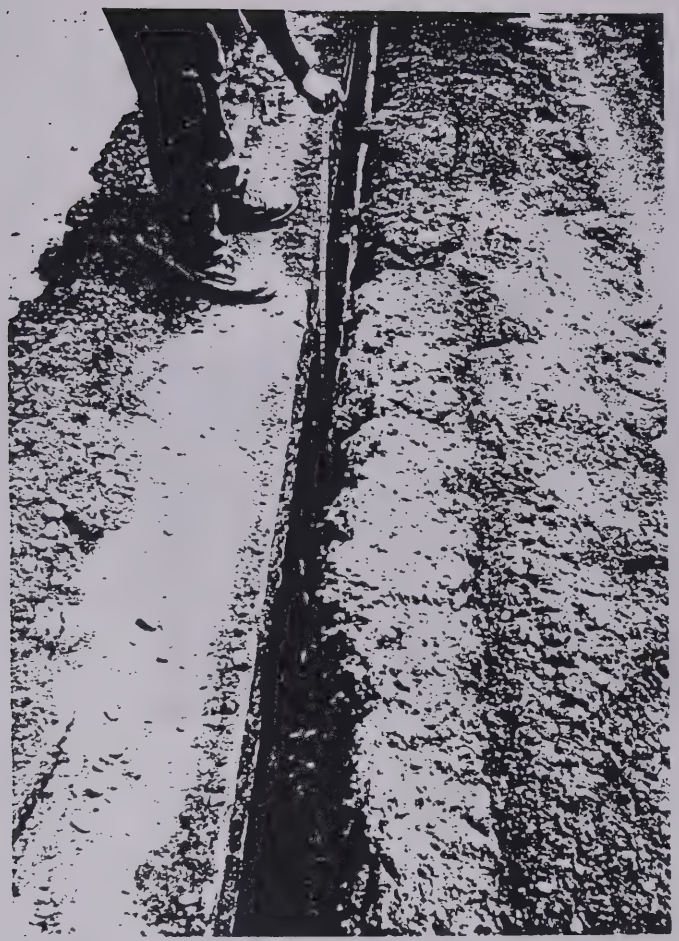


Photo No. 5. Route I-295
NB Shoulder, June 1988.

Standing water in trench.

Ground water level only 36"
below pavement surface.

Photo No. 6. Route I-295 NB Shoulder June, 1988
Installation of geocomposite edge drain.
Geocomposite drain held against concrete
pavement with shovel until 1st lift of
backfill is completed.

Photo No. 7. Route I-295 NB Shoulder June, 1988
Splicing of geocomposite edge drain sections.

Photo No. 8. Route I-295 NB Shoulder June, 1988
Compaction of 1st lift of backfill with modified ski-foot attachment to vibratory plate compactor.

Photo No. 9. Route I-295 NB Shoulder June, 1988
Backfilling of 2nd lift with motor grader.

Photo No. 10. Route I-295 NB Shoulder June, 1988
Compaction of 2nd backfill lift with
tires of motor grader.

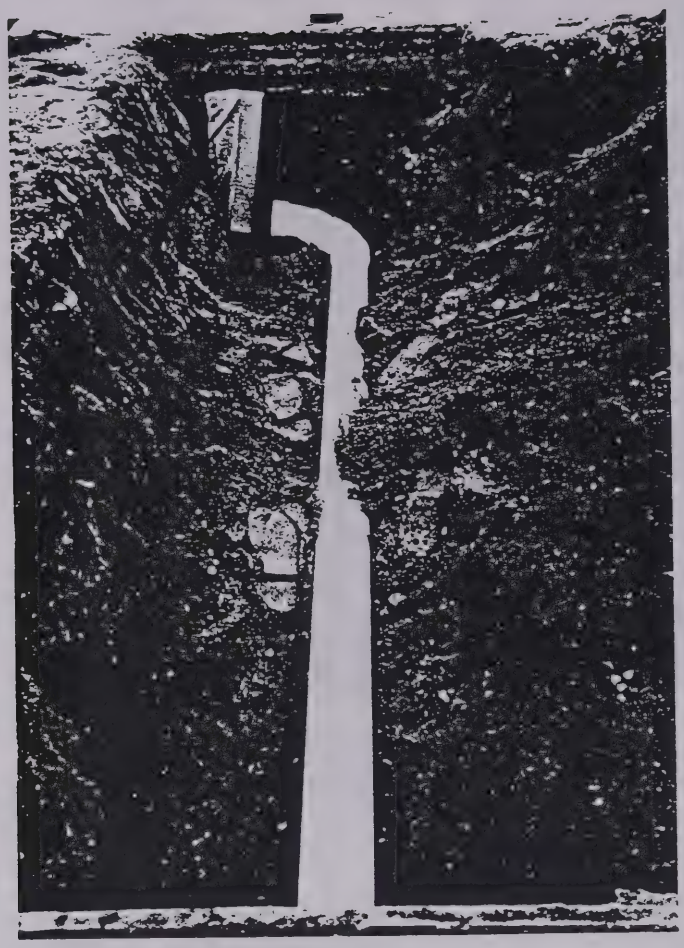


Photo No. 11. Route I-295
NB Shoulder June, 1988

Outlet fitting, 45° tee section and 4" dia. PVC outlet pipe for geocomposite edge drain.

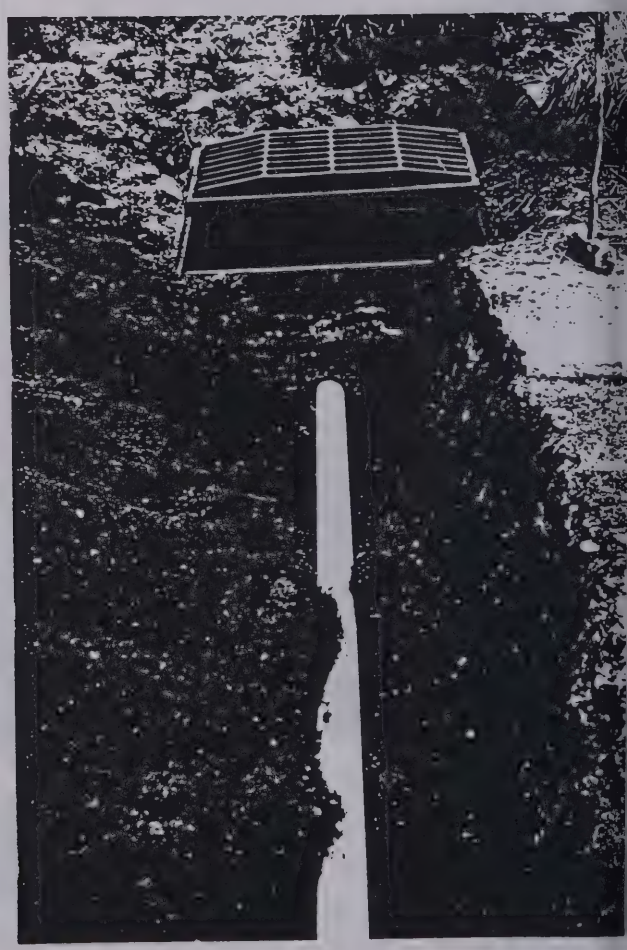


Photo No. 12. Route I-295 NB Shoulder
June, 1988

4" dia. PVC outlet pipe tied into existing catch basin.

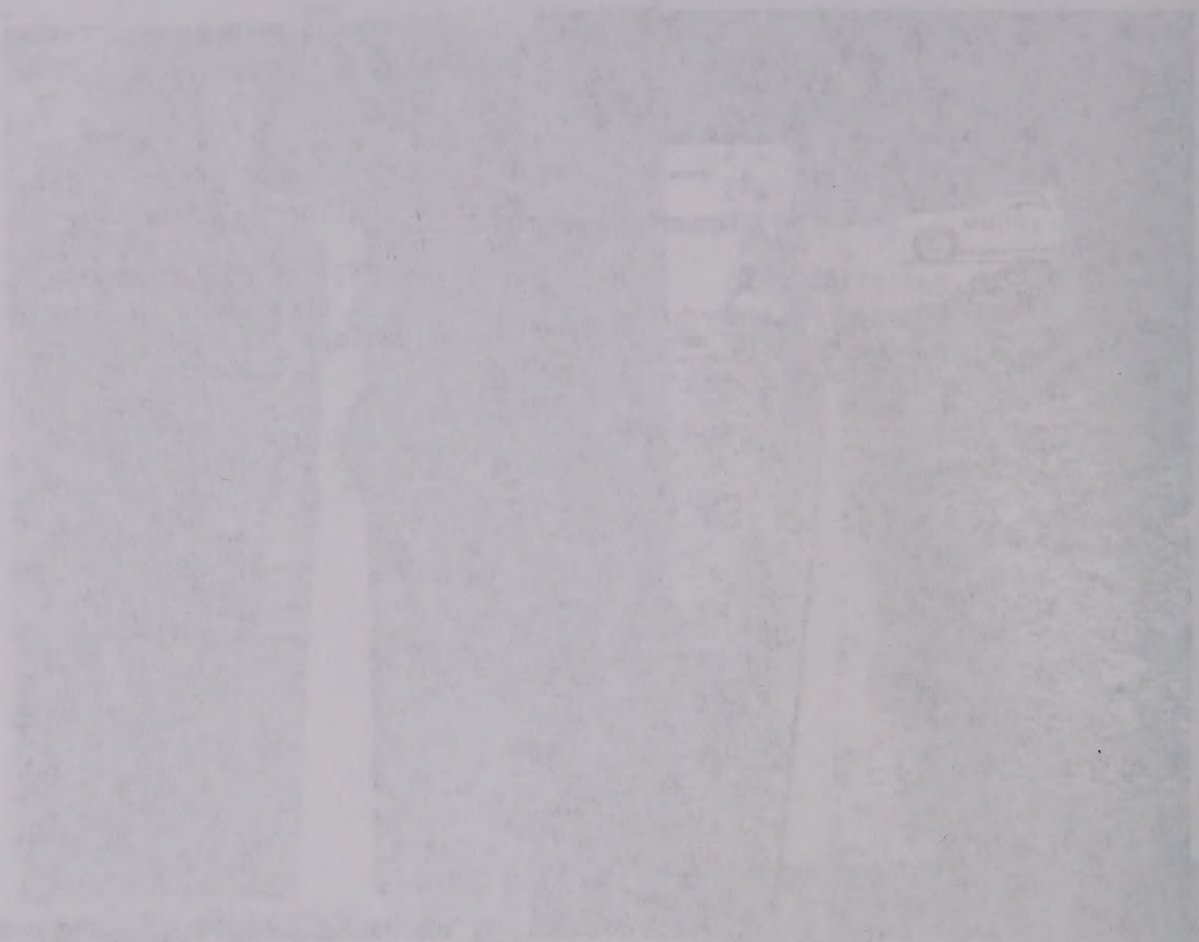
Photo No. 13. Route I-295
NB Shoulder June, 1988

Backfill of outlet pipe trench daylighted to sideslope ditch.

Photo No. 14. Route I-295
NB Shoulder, JUNE, 1988

Outflow from geocomposite outlet pipe after rain storm.

Note rodent screen.



NJDOT RESEARCH LIBRARY
3 4310 00003 1693